

CLAIMS

What is claimed is:

- 5 1. A method of bonding an element to a substrate, the method comprising the steps of:
 - a) providing a substrate having a generally flat surface,
 - b) placing two or more solder bumps having a predetermined volume on either the substrate or on the element, the bumps defining a single axis,
 - 10 c) determining a shape, size and location of two or more solder pads on the other of the substrate or element so as effect a predetermined orientation of the element at a predetermined angle with respect to the substrate during heating and melting of the solder bumps,
 - d) effecting a contact of the element with the substrate via the solder bumps, such that the element is secured to and supported on the solder bumps only, and
 - 15 e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to orient the element at a predetermined angle between angles greater than 0 and less than 90
 - 20 degrees with respect to the substrate by said heating alone.
2. The method according to claim 1 wherein the element is attached to a transfer device before the step d).
- 25 3. The method as defined in claim 1 including the step of providing means for asymmetrical flow of the solder bumps upon melting.
- 30 4. The method of claim 1 wherein an unequal force of the liquid solder surface tension about the solder bumps in a predetermined direction in accordance with the shape, size and location of the pads, during melting of the solder exceeds that of gravity and ensures the chip will rest at the predetermined angle and orientation.

5. The method as defined in claim 1, wherein the element after step (e) tilts until it makes contact with substrate.

6. The method as defined in claim 3, wherein the element after step (e) tilts until it makes contact with substrate.

7. The method of claim 3 wherein the pads are disposed on the element and the solder bumps are disposed on the substrate.

8. The method of claim 1 wherein at least two solder bumps are disposed on two pads in an asymmetric fashion such that upon melting the solder, a significantly greater amount of solder is melted one side of each pad than an opposite side of each pad about the solder bumps.

9. The method of claim 1 wherein the element comprises an opto-electronic component.

10. An assembly comprising a substrate and an element secured to the substrate at an angle with a solder, the assembly made by the method of claim 1.

11. The method of claim 1 wherein the step d) comprises contacting the element with the solder bumps, melting the solder bumps and solidifying the solder bumps to cause immobilization of the element on the solder bumps without a direct contact between the element and the substrate.

12. A method of bonding an element to a substrate, the method comprising the steps of:

- a) providing a substrate having a generally flat surface,
- b) placing two or more solder bumps having a predetermined volume on either the substrate or on the element, the bumps defining a single axis,
- c) providing at least two pads on the other of the substrate or the element for contacting with the solder bumps placed in step (b) wherein the size and location of

two or more solder pads on the other of the substrate or element is selected so as effect a predetermined orientation of the element at a predetermined angle with respect to the substrate during heating and melting of the solder bumps, the shape of the pads being asymmetric about the single axis when a contact is made between the substrate and the element,

d) effecting the contact of the element with the substrate via the solder bumps, such that the element is secured to and supported on the solder bumps only, and

e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity force and by surface tension force substantially about the axis defined by the solder bumps so as to orient the element at a predetermined angle between and including angles of 0 and 90 degrees with respect to the substrate by said heating alone.

13. A method as defined in claim 12, wherein each of the at least two pads are symmetric about two orthogonal axes, and wherein the solder bumps contact the pads and are secured thereto in an asymmetrical fashion such that the location of the solder bumps on the pad is substantially offset from the geometrical centre of the symmetric pad.

14. A method as defined in claim 12, wherein each of the at least two pads are symmetrical about a centre point and wherein the solder bumps contact the pads and are secured thereto in an asymmetrical fashion such that the location of the solder bumps on the pad is substantially offset from the geometrical centre of the pad.

15. A method as defined in claim 12, wherein the tilting displacement is caused primarily by surface tension of the solder so as to pull the element in a predetermined direction countering forces of gravity that would otherwise tilt the chip in a different direction.

16. A method as defined in claim 12 wherein the tilting displacement is caused by surface tension of the solder and gravity.

17. A method as defined in claim 12, wherein the element tilts until it makes contact with the substrate, and wherein the direction of tilt, is opposite to tilt that would

otherwise have occurred in the presence of gravity and absent the surface tension force of the solder.

18. An assembly made by the method steps of claim 17.

19. An element having two solder pads connected and supported by at least two solder bumps to two solder pads on a substantially planar substrate, the element being at predetermined second angle to the substrate, the angle being between 0 and 90 degrees, the element having been moved from a first angle into the second angle by heating of the solder bumps alone, in the absence of other fixturing to hold the element in said second predetermined angle during said heating, at least two of the solder pads on at least one of the planar substrate and the element being sized and located in such a manner as to allow surface tension forces of the solder upon melting to pull the element into the second predetermined angle in the absence of further machine or human intervention, wherein the first angle differs from the second predetermined angle by at least 10 degrees.

20. A method as defined in claim 12 wherein the surface tension force is greater than the force of gravity.